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S3E Presentation

S3E-1

Influences of two different types of El Niño events on aerosol concentrations in East Asia

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We examine the impacts of El Nino on aerosol concentrations in East Asia using 3-D global chemical transport model (GEOS-Chem) with fixed anthropogenic emissions for the past three decades (1980-2014). The model uses assimilated meteorological data from Modern-Era Retrospective analysis for Research and Applications (MERRA). First, we evaluate the model by comparing the observed and modeled aerosol concentrations including sulfate, nitrate, ammonium, BC and OC in surface air in East Asia. The results indicates that the model reproduces the spatial characteristics of the observed surface aerosol concentrations. We then select 10 El Nino events based on Oceanic Nino Index (ONI) from National Oceanic and Atmospheric Administration (NOAA)'s Extended Reconstructed Sea Surface Temperature (ERSST) dataset. We classify the types of these 10 El Nino events as 4 eastern Pacific (EP) El Nino and 6 central Pacific (CP) El Nino and quantify the different impacts of two type of El Nino events on aerosol concentrations in East Asia. Analysis of the simulated results shows that the EP- and CP-El Nino have different impacts on the surface aerosol concentrations in East Asia, which means that the East Asian air quality is affected differently by the type of El Nino.

S3E-2

Seasonality in anthropogenic aerosol effects on East Asian climate simulated with CAM5

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This study investigates the seasonality in anthropogenic aerosol optical depth (AOD) distributions and their effects on clouds and precipitation in East Asia with the Community Atmospheric Model version 5. The differences between the model experiments with and without anthropogenic emissions exhibit a northward shift of the maximal AOD change in East Asia from March to July and then a southward withdrawal from September to November, which are induced by East Asian monsoon circulation. Associated with the shift, the direct and semidirect effects of the anthropogenic aerosols are the most pronounced in spring and summer, with a maximum center in North China during summer and a secondary center in South China during spring. The cloud liquid water path and shortwave cloud forcing changes, however, are the weakest in North China during summer. The indirect effect is the strongest in South China during spring, which is related to the large amount of middle-low level clouds in cold seasons in East China. A positive feedback between aerosol induced surface cooling and low-level cloud increase is identified in East China, which acts to enforce the aerosol indirect effect in spring. Accordingly, the climate response to the anthropogenic aerosols is also characterized by a northward shift of reduced precipitation from spring to summer, leading to a spring drought in South China and a summer drought in North China. The spring drought is attributed to both direct and indirect effects of the anthropogenic aerosols, while the summer drought is primarily determined by the aerosols' direct effect.

S3E-3

Submicron aerosol size distribution and CCN number concentration over the Yellow Sea measured on a meteorological research vessel, GISANG 1

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The Yellow Sea is the region affected by air mass transported from both China and Korean Peninsula. However, aerosol measurement over the Yellow Sea is very scarce. There are some studies that measured only aerosol size distribution or cloud condensation nuclei (CCN) number concentration, but Few studies have simultaneously measured both aerosol size distribution and CCN number concentration over the Yellow Sea. Therefore, in this study, we tried to understand about aerosol size distribution and their relationship with CCN number concentration over the Yellow Sea.

Gisang 1, research vessel of national institute of meteorological sciences (NIMS), cruised over the Yellow Sea of Korea in April and May 2017. Aerosol number concentrations, number size distribution, and CCN number concentration were respectively measured by two condensation particle counters (CPC; TSI 3772 and TSI 3776), a scanning mobility particle sizer (SMPS; TSI 3936L10), and CCN counter (DMT; CCN-100) on board Gisang 1. Meteorological parameters like temperature, relative humidity, wind speed, wind direction, etc. were also continuously measured on the vessel. Because the vessel continuously emitted particulate matter and speed of the vessel was about 6-7 m s-1, the data measured when vessel did not move or the wind speed in the direction of the vessel movement was higher than 6 m s-1 were excluded.

Average number concentration of aerosols larger than 10 nm was about 7500 cm-3 and average CCN number concentration at 0.65 supersaturation was about 4800 cm-3. We applied positive matrix factorization (PMF) analysis to aerosol size distribution data. The PMF analysis decomposes a data into factor contributions and factor profiles. In this study six factors were used for the PMF analysis, and the coefficient of determination between the original SMPS data and the data reconstructed from 6 factors was 0.95. The first two of the six factors represent nucleation mode, the next three represent accumulation mode, and the last one represents coarse mode. Six factors were different according to elements such as wind direction and meteorological phenomenon. Most of CCN number concentration at 0.65 supersaturation seemed to be accounted for by latter four factors (accumulation and coarse mode).

CCN closure study was also carried out. When 0.2 used as kappa value, indicating aerosol hygroscopicity, the estimated CCN number concentrations were the closest to the observed CCN number concentration. Based on the measured CCN number concentration and aerosol size distribution, CCN spectra over the Yellow Sea can be suggested, and more comprehensive analysis results will be shown at the conference.

S3E-4

The contribution of large urban areas to local CO2 anomalies retrieved from OCO-2 and GOSAT spaceborne observations

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Urban areas are currently responsible for nearly 70% of global CO2 emissions worldwide. Such contribution emphasizes the important role of cities in global climate change as the exceeded concentration of atmospheric CO2 has already led to increase CO2-related radiative forcing by 20%. Moreover, severe changes in CO2 concentration due to urban emissions contributed to carbon cycle modification at local and global scales. The impacts of urban CO2 emissions to global climate will be most likely enhanced in future since most of modern estimates on urbanization prospects concur that urban areas will keep expanding in future. Despite the high importance of the urban footprint in CO2 global concentration, variations of CO2 across different cities worldwide are yet not well understood. This issue is explained by the high requirements on measurement resolution and accuracy for urban CO2 measurements. Even largest emission sources of CO2 result in relatively weak increase in background CO2 concentration (< 0.25%). Recent advancements in satellite remote sensing instruments gradually allowed to focus on urban CO2 research on regional and global scales with reasonable limitations. This study deploys the advantages of spaceborne observations to delineate urban areas and to quantify CO2 anomalies over the largest cities worldwide. Urban boundaries are determined using numerical threshold for stable-lights observations from The Defense Meteorological Satellite Program-Operational Linescan System (DMSP-OLS). CO2 anomalies are retrieved over more than 100 urban areas in the period from October 2014 to December 2016 using high-resolution OCO-2 (Orbiting Carbon Observatory) observations (1.25 x 2 km) supported by GOSAT (The Greenhouse Gases Observing Satellite) measurements. We present the variations of urban CO2 anomalies (XCO2urb) and show good agreement in urban CO2 signal extraction between OCO-2 and GOSAT observations for 21 urban areas where enough measurements were available over the period of study. Observations from both satellites reveal that strong urban enhancements of CO2 are evidenced over northern hemispheric cities (notably from China, USA, Japan, South Korea, India and Pakistan). Five cities with highest XCO2urb from OCO-2 top list are Shanghai/Suzhou (7.11 ppm), Asansol (5.99 ppm), Linyi (5.90 ppm), Nantong (5.59 ppm) and Tianjin (5.25 ppm), most of which (except Asansol) are located in China. Similarly to OCO-2 results, highest XCO2urb values are found over the Chinese cities of Jinan (6.10 ppm), Chengdu (4.69 ppm), Wuhan (4.55 ppm), Hangzhou (4.33 ppm) and Shanghai/Suzhou (4.10 ppm). Smallest (i.e. negative) values of XCO2urb are evidenced over the cities in southern hemisphere. The presence of strong oceanic and biogenic sinks (especially in summer) in southern hemisphere most likely outweigh CO2 anthropogenic urban signal. Additionally, we identify weak positive relationship between XCO2urb from OCO-2 with urban heat island temperature (correlation coefficient is 0.34) and population count (correlation coefficient is 0.35). This finding based on such global study supports the phenomenon of city as anthropogenic hotspot that increases CO2 concentration and augments local surface temperature. More detailed study with several independent datasets on population count and urban heat island temperature is required to examine this phenomenon closely.

S3E-5

Comprehensive analysis of urban aerosol properties and their CCN activity during the KORUS-AQ campaign

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Aerosol emitted from various sources like ocean, biomass burning and industrial emissions affects air quality, one of the rising issues all over the world. Also it can act as cloud condensation nuclei (CCN) which is closely related to cloud-aerosol-interaction problem so it is regarded as important factor on climate change. However understanding aerosol properties and their effect on climate change and air pollution was still limited due to the diverse temporal-spatial distribution and sources.

As an effort to understand aspects of air quality problem, the KORea-United States Air Quality study (KORUS-AQ) conducted in and around Korean Peninsula during May-June 2016 with comprehensive set of measurements from aircraft, ground sites, ship and satellites with air quality model. Among them, results from ground-based measurement which was performed in Olympic park, Seoul, the representative urbanized area in Korea, will be presented in the conference. During the campaign, aerosol and CCN number concentration (N_CN and N_CCN), aerosol number size distribution, growth factor and chemical components of aerosols were measured by condensation particle counter (CPC), CCN counter (CCNC), scanning mobility particle counter (SMPS), humidified Tandem Differential Mobility Analyzer (HTDMA) and aerosol mass spectrometer (AMS), respectively.

Average N_CN, N_CCN and geometric diameter (D_g) during the campaign were lower than MAPS-Seoul campaign, pre-campaign for KORUS-AQ, and even the long-term observation in Yonsei university, Seoul. Aerosol hygroscopicity parameter, κ, derived by growth factor from HTDMA ranged 0.11-0.24 lower than previous campaign. It is similar to other urban areas in East Asia like Beijing. Mixing state of the aerosol can also be investigated by HTDMA output and the externally mixed aerosols occupied high percentage during the campaign. It implies that uncertainties of CCN prediction which is usually conducted with simple internally mixed assumption can be reduced by consideration of aerosol mixing state especially for urban aerosols.

During the campaign, there were some special periods classified by air mass back trajectories and meteorology and different aerosol properties were shown in each period. Organic-dominant chemical composition resulted in low aerosol hygroscopicity and N_CCN on a period when local sources prevailed despite of similar N_CN compared to other periods whereas high aerosol hygroscopicity and N_CCN were shown because of inorganic-dominant chemical composition and large D_g during the period when mainly affected by transported sources from China.

S3E-6

Interannual variation of air quality over north China in wintertime

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A Regional Air Quality Model System (RAQMS) was adopted to simulate the interannual variation of air quality over north China in wintertime. The Januarys of 2011 and 2013 were chosen as studying period. Various observational data from China National Environmental Monitoring Center (CNEMC) and the Acid Deposition Monitoring Network in East Asia (EANET) were used for model validation. The comparison result demonstrated that RAQMS was able to reproduce the particulate matter (PM) concentrations and visibilities over north China and downwind areas in both winters. The monthly mean PM10 concentration in the January of 2011 was predicted to be about 30-90 μ g m-3 in the Beijing city. The mean PM10 concentrations over Tianjin, southern part of Hebei province, and northern part of Shandong province were higher, ranging from 90 μ g m-3 to 150 μ g m-3. In contrast, air quality was much worse in the January of 2013, with the mean PM10 concentration being about 100-200 μ g m-3 in Beijing, 200-300 μ g m-3 in both Tianjin and southern Heibei province, and 150-250 μ g m-3 in northern Shandong province, nearly 2-3 times higher than that in 2011. Different meteorological conditions in these two winters were responsible for such differences. The stagnant air mass dominated north China in January 2013, resulting in small wind speed and weak vertical diffusion of pollutants. The model result showed a similar fine particle fraction in both winters, when PM2.5 accounted for about 90% of total PM10 mass, in which about 25% from inorganic aerosols, about 25% from carbonaceous aerosols, and about 50% from primary anthropogenic PM2.5. Although there was strong interannual variation of winter air quality in north China, no obvious differences were found in downwind PM concentrations in the Korean Peninsula and west Japan, suggesting the limited transport effect of emissions from north China during the study periods.